KWOC
Tidal power (1a)

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

TIDAL POWER IN BRITISH COLUMBIA

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B.C. Hydro/B.C.

TIDAL POWER IN BRITISH COLUMBIA

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SUMMARY

1. A recent study by B.C. Hydro looked at 13 potential tidal power sites on the B.C. coast.

2. If all these sites were developed, they could provide an estimated annual energy output of about 13,100 million kWh which is approximately equal to the annual output of the G.M. Shrum plant on the Peace River.

3. Development of the two most attractive tidal power sites would provide about 2200 million kWh of energy per annum. The unit cost of energy from these sites would be about 7 to 9 times more expensive than the cost of energy from other generation options available to B.C. Hydro.

4. Tidal projects could have significant impacts on the marine environment, although this aspect has not yet been examined by B.C. Hydro.

5. Because of the high costs of tidal power when compared to hydroelectric or coal-fired alternatives, there is no incentive to pursue more detailed studies at this time. However, a watching brief will be maintained to periodically reassess tidal power as a generation option.

I. INTRODUCTION

For centuries small tidal power plants have been used to perform such tasks as pumping water and grinding grain; however, these plants largely disappeared with the advent of steam power. The recent rapid escalation in the cost of conventional energy sources has created renewed interest in the large scale development of tidal power as an alternative energy source.

The first major tidal power development was the La Rance plant, completed in 1966 near St. Malo in France. This plant consists of 24 turbine-generator units having a total generating capacity of 240 MW. In the Soviet Union, a small experimental powerplant with a capacity of 400 kW has been constructed near Murmansk; and several smaller plants have been constructed in China. The British have been studying the Severn Estuary for tidal power development, but indications are that the costs would be higher than for fossil fuel or nuclear energy.

In Canada, studies of tidal power development have focussed on the Bay of Fundy which has the greatest tidal fluctuations of any area in the world. A recent study carried out jointly by the Governments of Canada, Nova Scotia, and New Brunswick has determined that the cost of tidal energy from the Bay of Fundy development could be marginally competitive with fossil fuel generation in that area. Studies are continuing.

II. DEVELOPMENT CONCEPTS FOR TIDAL POWER

The objective of tidal power development is to generate electrical energy from the natural daily fluctuations in the level of the oceans. These fluctuations are caused by the gravitational action of the moon and the sun on the earth.

Tidal energy is harnessed most simply by constructing a dam across the entrance to a tidal basin or inlet. The dam incorporates a powerhouse and sluiceways which are opened when the tide is rising in order to allow water to flow into the tidal basin. When the tide reaches maximum level, the sluiceways are closed, thus trapping the water in the tidal basin behind the dam. As the water level on the ocean side of the dam drops, a head difference is developed between the ocean and the stored water behind the dam. When the head difference is large enough, gates are opened to hydraulic turbine-generator units in the powerhouse and water is gradually released from the basin to the ocean through the

turbines, thereby generating electrical energy. As water is released, the water level in the basin drops until it reaches a minimum level below which the turbine cannot operate. The cycle is repeated by closing the turbine gates and opening the sluiceways to refill the tidal basin on the next rising tide.

In the above cycle generation can take place for somewhat less than 50 per cent of the tidal cycle. A number of schemes involving refinements such as double basins or pumping have been put forward to smooth out these generation peaks. However, studies for Canada's east coast have shown that single basin one-way generation is more likely to be economically attractive than more complex schemes.

III. POTENTIAL TIDAL SITES IN B.C.

The coastline of British Columbia has many inlets and bays which could be used as storage basins in tidal power developments. Unfortunately, the mean tidal range along the B.C. coast is only 2 to 5 metres (m) which is generally less than what is considered favourable for tidal power development. By comparison, the mean tidal range in the Bay of Fundy is about 10 to 12 m and at La Rance it is 8.4 m.

A study was carried out recently by B.C. Hydro to identify potential tidal power sites along the coast. The major factors considered in the selection of potential sites were the magnitude of the tidal range, the size of the tidal basin for water storage, and the size of dam required to close off the tidal basin. Using these criteria, 13 potential sites were identified (Figure 1). The table below summarizes the relevant data for these potential sites.

POTENTIAL TIDAL POWER SITES IN BRITISH COLUMBIA

	Site	Mean Tidal Range (m)	Basin Area (km^2)	Installed Capacity (MW)*	Annual Energy Output (Million kWh)
1.	Portland Canal	5	209	738	2264
2.	Observatory Inlet	4.7	212	662	2030
3.	Khutzeymateen Inlet	4.7	27	85	259
4.	Work Channel	4.7	80	250	766
5.	Prince Rupert	4.9	10	34	104
6.	Skeena River	5.3	31	123	377
7.	Gardner Canal	4.2	171	426	1307
8.	Laredo Inlet	3.5	66	114	350
9.	Knight Inlet	3.8	232	474	1452
10.	Jervis Inlet	3.5	158	249	763
11.	Sechelt Inlet	3.5 at mouth 2.0 inside	106	54	167
12.	Jervis and Sechelt	3.5	430	677	2075
13.	Howe Sound	3.3	282	395	1210
			TOTALS	4281	13124

* 1 MW = 1,000 kW

For the purpose of estimating costs for typical tidal power developments on the B.C. coast, two of the most attractive sites from the above inventory were selected for more detailed study. The selected sites were Observatory Inlet on the north coast near Prince Rupert, and Sechelt Inlet on the south coast near Vancouver.

IV. PROJECT LAYOUTS AND COST ESTIMATES

The project layouts for the Observatory Inlet and Sechelt Inlet sites are shown in Figures 2 and 3, respectively. These layouts are based on typical design criteria considered in the Bay of Fundy study.

The powerhouse for each site would form part of the dam and would consist of a number of concrete caisson sections which would contain one or two turbine-generator units. Each section could be constructed on land and then floated in to the project site where it would be sunk with ballast onto a prepared foundation. Figures 4 and 5 are sectional drawings showing typical construction details of the powerhouse for each site. The powerhouse for the Observatory Inlet site would contain 70 generating units with a total capacity of 662 MW. The Sechelt Inlet powerhouse would contain 9 units with a total capacity of 54 MW.

The sluiceways would consist of vertical lift sluicegates which would also be constructed in prefabricated concrete caissons. For the Observatory Site the sluiceways would be mounted on top of the powerhouse sections. At the Sechelt Inlet site which is somewhat shallower, the sluiceways would be placed so as to form a separate portion of the dam across the inlet.

The remainder of the tidal barrier or closure dam for each site would be a dyke constructed from dumped rockfill. These dykes would be designed to prevent leakage and also to withstand severe wave action. A road would be constructed across the top of the dykes to provide access to the powerhouse.

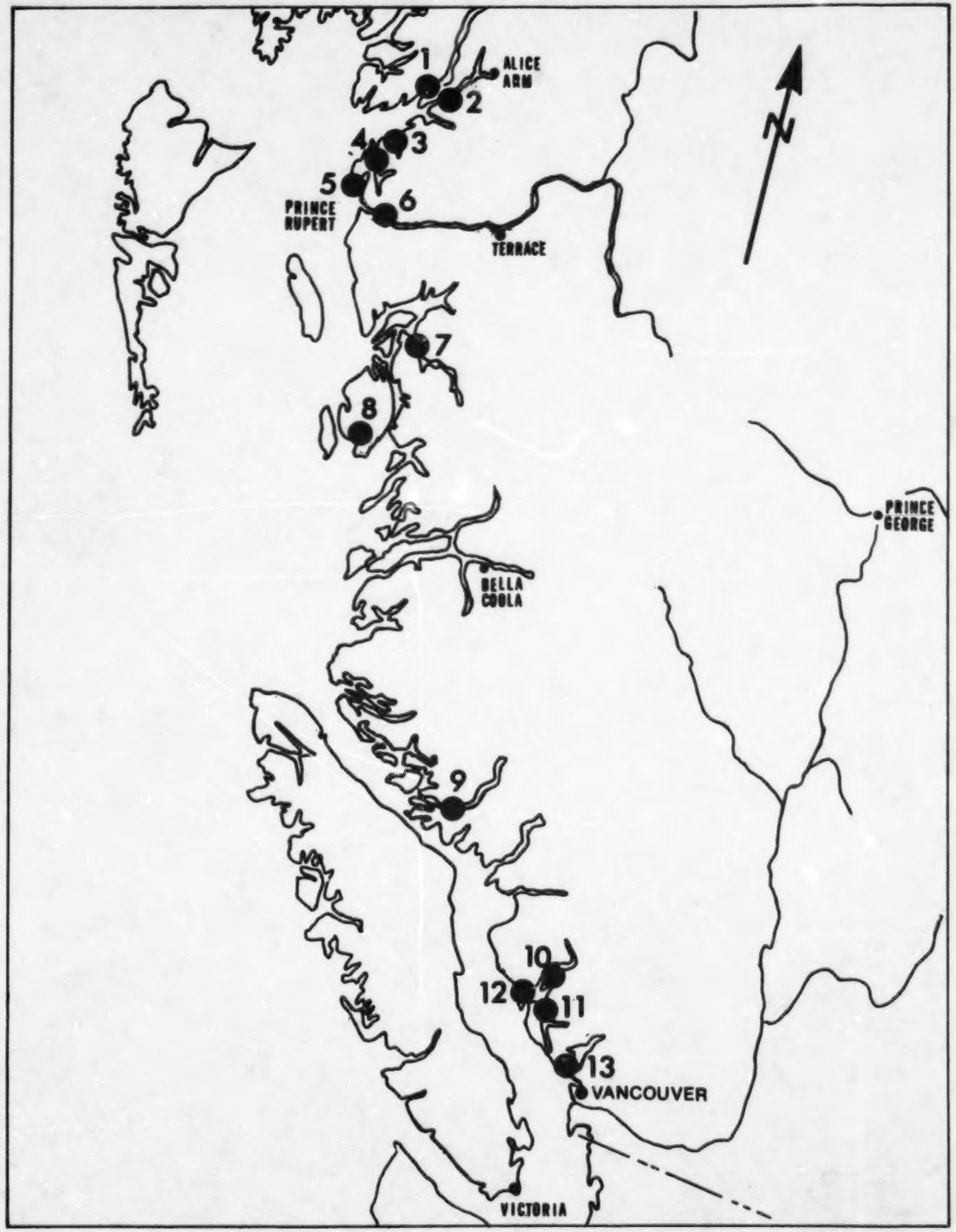
Based on the above layouts for the two projects, total capital costs and annual energy outputs were estimated as shown in the table below:

Site	Capital Cost* ($ millions)	Annual Energy Output (Million kWh)
Observatory Inlet	2498	2030
Sechelt Inlet	243	167

* At 1978 price levels.

The cost estimates do not include transmission. Also excluded from the cost estimates are the costs of navigation locks or other special facilities which may be required.

Based on the above estimates, the cost of tidal energy would be about 7 to 9 times more expensive than other generation options available to B.C. Hydro.

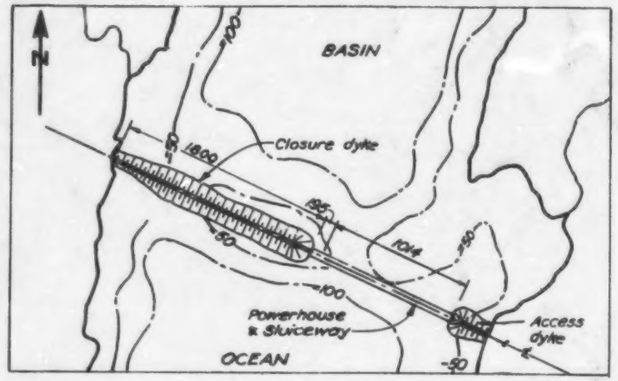


LIST OF SITES	
1	Portland Canal
2	Observatory Inlet
3	Khutzeymateen Inlet
4	Work Channel
5	Prince Rupert
6	Skeena River
7	Gardner Canal
8	Laredo Inlet
9	Knight Inlet
10	Jervis Inlet
11	Sechelt Inlet
12	Jervis and Sechelt
13	Howe Sound

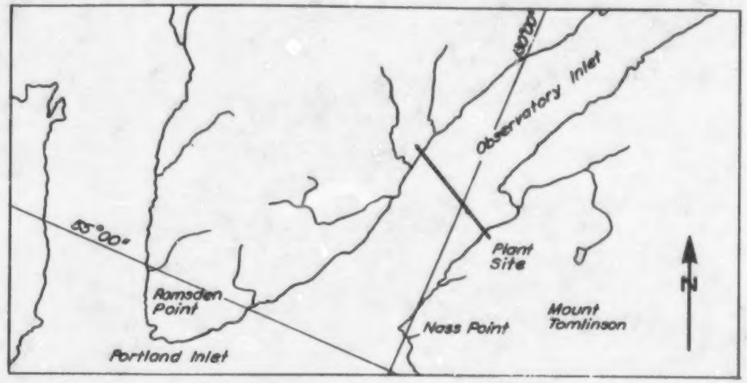
● SITES SELECTED FOR RANKING STUDY

TIDAL POWER IN BRITISH COLUMBIA

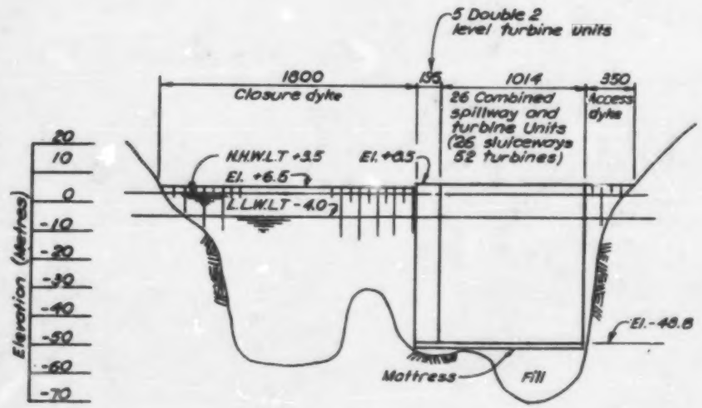
AREA LOCATION PLAN



PLAN
Scale: A



LOCATION PLAN
Scale: B



PROFILE ALONG CENTRELINE
Horizontal Scale: A
Vertical Scale: As shown

NOTES:

1. ALL DIMENSIONS IN METRES.
2. ELEVATIONS REFERENCED TO MEAN SEA LEVEL.
3. DATA OBTAINED FROM CANADIAN HYDROGRAPHIC SERVICE CHART NO. 3933.
4. INSTALLED CAPACITY - 70 UNITS, TOTAL PLANT CAPACITY - 6GE MW.
5. SLUICEWAY 26 GATES 12.2M X 12.2M.
6. SEE PLATES 3-2, 3-3, 3-7 FOR DETAILS OF STRUCTURES.
7. H.H.W.L.T. - HIGHER HIGH WATER LARGE TIDES.
   L.L.W.L.T. - LOWER LOW WATER LARGE TIDES.

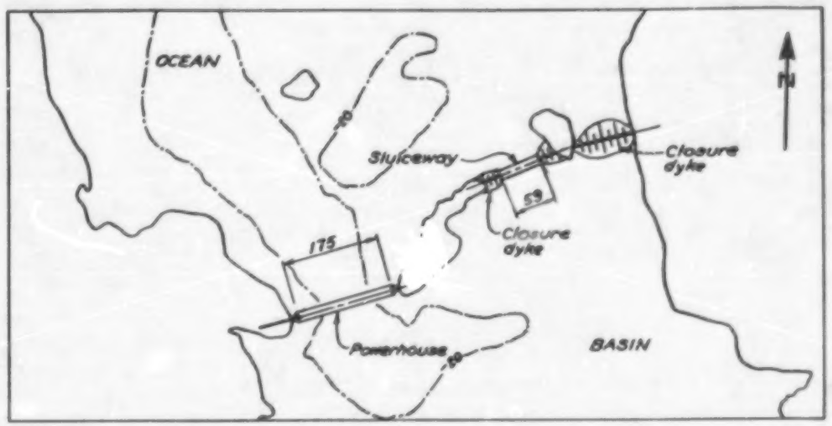
Scale: B 2000 0 2000 4000 6000 Metres

Scale: A 800 0 800 1600 2400 Metres

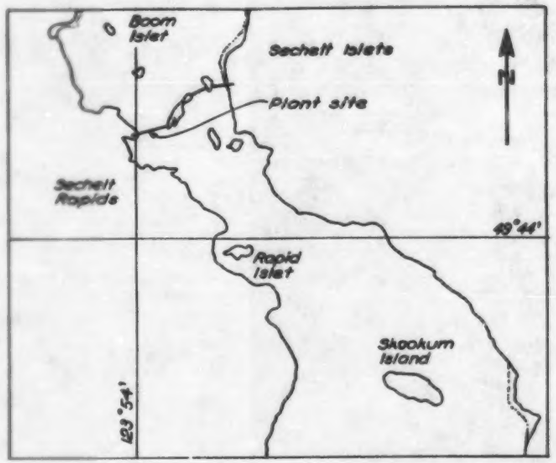
TIDAL POWER IN BRITISH COLUMBIA

OBSERVATORY INLET

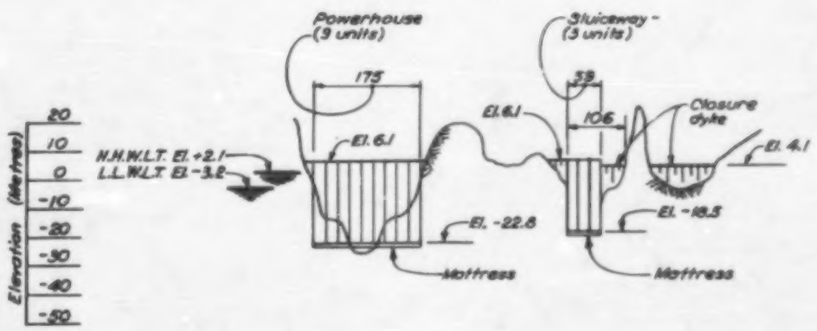
PLAN AND PROFILE



PLAN
Scale: A



LOCATION PLAN
Scale: B



PROFILE
Horizontal Scale: A
Vertical Scale: As shown

NOTES:

1. ALL DIMENSIONS IN METRES.
2. ELEVATIONS REFERENCED TO MEAN SEA LEVEL.
3. DATA OBTAINED FROM CANADIAN HYDROGRAPHIC SERVICE CHART NO. 3589.
4. INSTALLED CAPACITY 9 UNITS, TOTAL PLANT CAPACITY = 64 MW.
5. SLUICEWAY - 3 GATES - 12.2M X 12.2M.
6. SEE PLATES 3-5, 3-6, 3-7 FOR DETAILS OF STRUCTURES.
7. H.H.W.L.T. - HIGHER HIGH WATER LARGE TIDES.
   L.L.W.L.T. - LOWER LOW WATER LARGE TIDES.

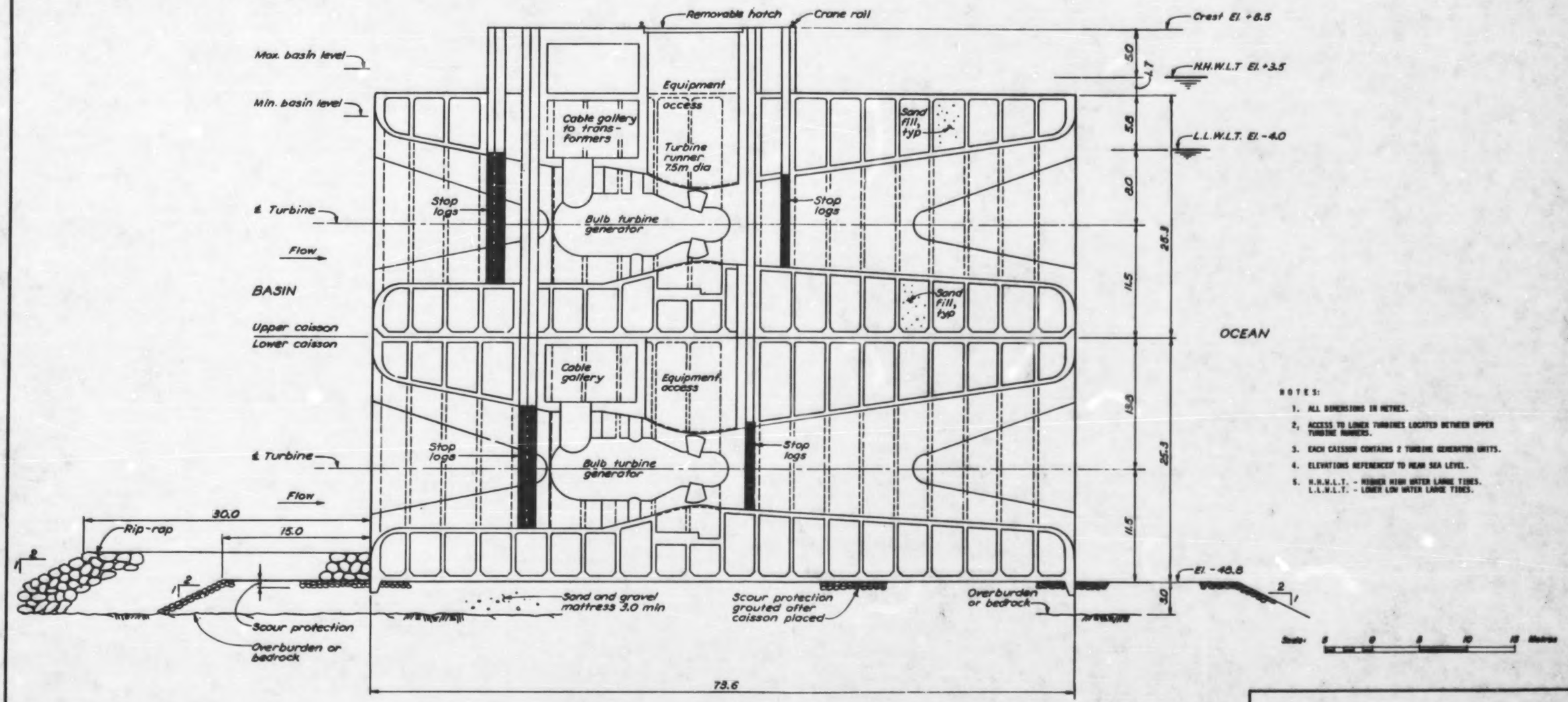
Scale-B 300 0 300 600 900 1200 Metres

Scale-A 100 0 100 200 300 400 Metres

TIDAL POWER IN BRITISH COLUMBIA

SECHELT INLET

PLAN AND PROFILE



NOTES:

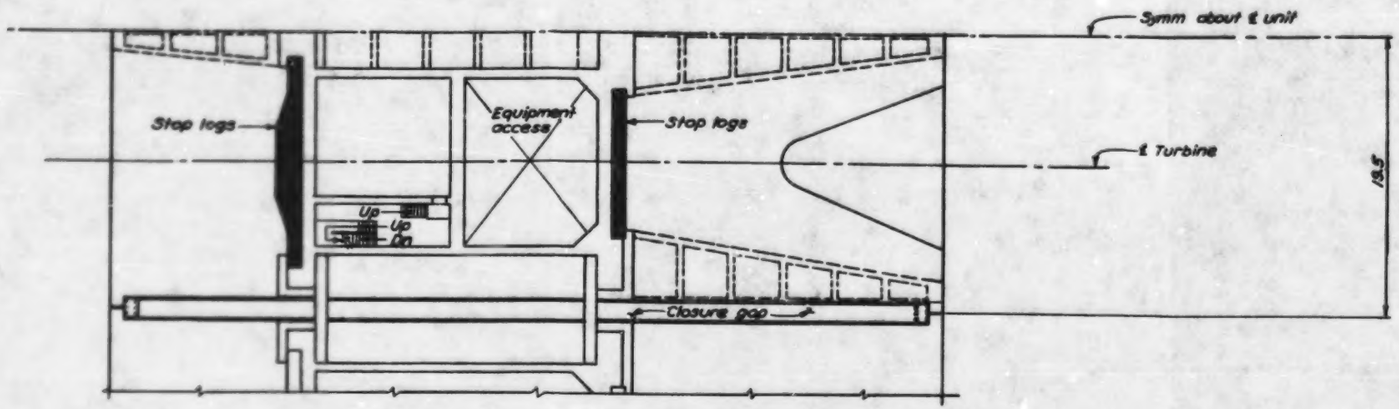
1. ALL DIMENSIONS IN METRES.
2. ACCESS TO LOWER TURBINES LOCATED BETWEEN UPPER TURBINE RUNNERS.
3. EACH CAISSON CONTAINS 2 TURBINE GENERATOR UNITS.
4. ELEVATIONS REFERENCED TO MEAN SEA LEVEL.
5. H.H.W.L.T. - HIGHER HIGH WATER LARGE TIDES.
   L.L.W.L.T. - LOWER LOW WATER LARGE TIDES.

SECTION THROUGH ℄ TURBINES

TIDAL POWER IN BRITISH COLUMBIA

OBSERVATORY INLET

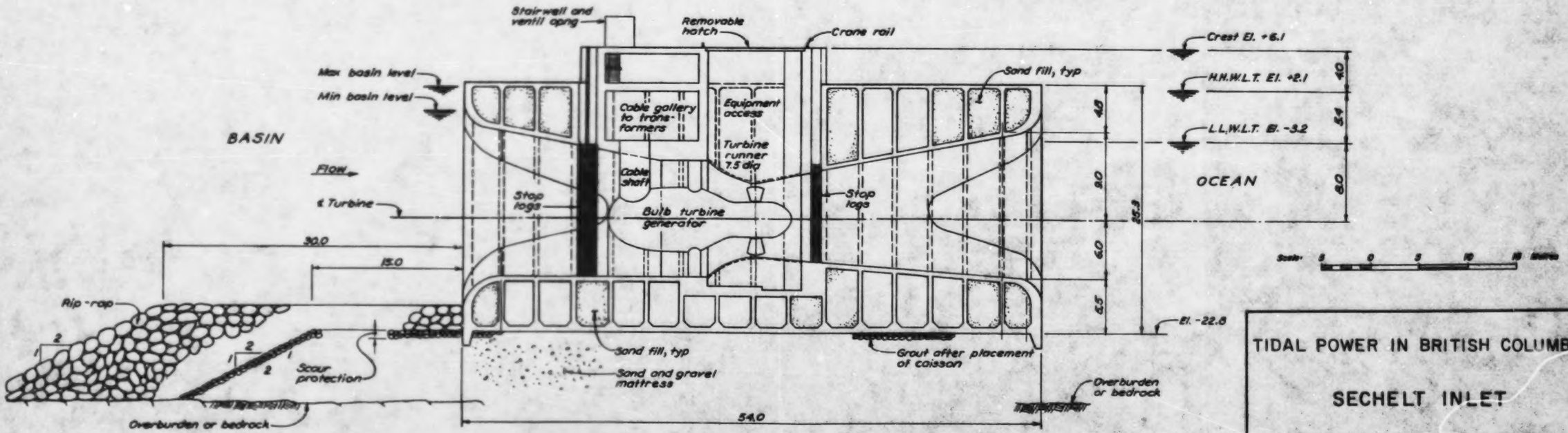
TYPICAL TWO-LEVEL POWERHOUSE



PLAN – SUPERSTRUCTURE

NOTES:

1. ALL DIMENSIONS IN METRES.
2. EACH CAISSON CONTAINS 2 TURBINE GENERATOR UNITS.
3. ELEVATIONS REFERENCED TO MEAN SEA LEVEL.
4. H.H.W.L.T. - HIGHER HIGH WATER LARGE TIDES.
   L.L.W.L.T. - LOWER LOW WATER LARGE TIDES.



SECTION THROUGH ℄ TURBINE

TIDAL POWER IN BRITISH COLUMBIA

SECHELT INLET

TYPICAL SINGLE-LEVEL POWERHOUSE